An Argument for Fully Engineered Post-Frame Buildings

About the Author

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A Near-Fatal Collapse

On December 16, 2010, 66-year-old dairy farmer Cyril Myren was recovering at home from serious injuries. Only four days earlier, a section of his two-year-old post-frame dairy freestall barn collapsed on top of him, leaving Cyril with two cracked ribs and extensive bruising. His son Todd, age 33, was also injured, suffering a head wound and other injuries. While the two men were attempting to move animals out of a portion of the barn that had already failed, additional bays collapsed, trapping Todd until emergency personnel arrived. Todd lost a significant amount of blood during the ordeal. According to Cyril, they were both fortunate to survive, though unfortunately, some of their animals did not.

Engineering Gone Missing

After inspecting the partially collapsed barn, it was clear that the structure suffered from major weaknesses due to insufficient engineering. Cyril was frustrated and angry, believing he had purchased a properly engineered building. For him, a "properly engineered" building meant one designed through a complete, thorough engineering process—a fully engineered building.

What “Fully Engineered” Really Means

A fully engineered building is achieved by following three essential structural design steps:

- **Step 1:** Calculate all loads and load combinations the building must withstand.
- **Step 2:** Analyze how these loads are distributed to every building element—a process called load path analysis.
- **Step 3:** Select components and connections capable of handling the forces they will experience. This step often influences earlier analyses, making the structural design process iterative rather than strictly linear.

What Defines a Fully Engineered Building?

A fully engineered building is one in which the interaction of all structural components is properly considered during analysis. The resulting forces determine the correct sizes for each component. In contrast, non-engineered designs do not account for individual component loads or strengths, and partially engineered buildings lack the comprehensive approach of a fully engineered design.

Consequences of Inadequate Engineering

The collapse of the Myren barn, along with five other buildings inspected that day, was due to unbalanced snow loads—drift and sliding snow—that should have been anticipated in the design. None of the buildings had been fully engineered.

Systemic Issues in Agricultural Building Construction

Many agricultural building companies neither employ engineers nor hire them to perform crucial structural calculations. As a result, numerous agricultural buildings are constructed each year with undersized components that cannot handle expected loads.

Problems with Non-Engineered Designs

Companies constructing non-engineered buildings often copy or alter designs seen elsewhere. This practice neglects the fact that wind and snow loads depend on a building's size, shape, orientation, location, local topography, and nearby structures. Loads can also combine in various ways, making it essential for buildings to withstand all possible scenarios.

Characteristics of Non-Engineered Building Design

Failure to Address Load Combinations

Non-engineered designs frequently fail to consider all possible load combinations. This oversight is a defining flaw, leading to damage from wind and unbalanced snow loads—damage that fully engineered buildings are designed to avoid.

Poor Connections Between Components

Non-engineered structures often feature weak connections between components. The stresses around fasteners like bolts, screws, and nails are complex, affecting fastener size, spacing, and placement. Builders mimicking other designs rarely achieve proper connection details, resulting in failures triggered by improper assembly.

Origins of Building Companies and Their Impact

Many building companies are started by individuals who once worked for companies selling fully engineered packages. While entrepreneurship is admirable, it does not ensure that new companies maintain fully engineered standards.

Risks Stemming from Inadequate Experience in Building Design

When individuals with only construction experience begin designing buildings without engineering expertise, the results can be alarming.

These individuals may believe prior experience is enough to construct safe buildings. However, participating in construction does not make someone an expert in building design, and designing a building does not guarantee expertise in safe construction.

Common Gaps in Understanding Among Industry Professionals

Few builders, architects, code officials, or even nonstructural engineers fully grasp the complexities of properly engineered post-frame building systems. Many building elements serve multiple functions that may not be obvious to those without specialized experience.

Lack of Expertise in Load Analysis and Connection Design

Builders often do not know the specific loads their components must withstand or the available methods to resist those loads. They also may lack the expertise needed to properly size components and design their supports and connections.

Consequences Observed in Field Failures

Failures such as those in Myren's barn often feature severely under-designed interior columns, many of which had an allowable axial design load of zero, resulting in buckling. Other deficiencies included lack of sideway control between columns and trusses, no consideration for drifting snow loads, and improper truss web bracing. Continuous lateral restraint (CLR) systems used to brace longer web members were installed incorrectly, lacking diagonal bracing, which led to web buckling and truss failure.

Misuse of Bracing Systems

The greater concern is not only improper CLR installation, but the use of CLR systems where they are not appropriate. For buildings with trusses spaced six feet or more apart, compression webs should be braced with T- or L-bracing. Reliance on CLR systems reflects poor planning rather than sound engineering.

Bracing Systems and the Risks of Progressive Collapse

In residential construction, where trusses are spaced less than four feet apart, L- or T-bracing offers advantages in lumber use and stability, and can be installed conveniently from the ground. These braces also help prevent progressive collapse. CLR systems, however, present risks: if a truss fails, the CLR pulls on adjacent trusses, potentially triggering a domino-like collapse across the roof until it reaches a supporting wall.

Impact on Building Owners

Investigations have shown that many farmers believe their buildings are safe and adequately designed, unaware of the risks from improper bracing and truss spacing. This misconception exposes them to significant operational risks.

Misconceptions About Building Safety

Many farmers wrongly believe they have purchased a properly engineered building; in some cases, they are intentionally misled, which is unethical and possibly criminal.

Issues With Design Assumptions

Farmers are often quoted a “balanced design snow load,” which is used in truss design software by lumber yard employees. This gives the false impression of a fully engineered building, but such trusses rarely account for all relevant loads, proper connections, or bracing.

Complexity of Building Systems

Trusses are just one part of a building system—each element must be engineered, with attention to their unique interactions.

Building Code Exemptions for Agriculture

The International Building Code (IBC) covers agricultural buildings, but many states exempt “buildings used exclusively for farming purposes” from all such provisions.

Consequences of Exemption

Builders may tell farmers they do not need engineering for agricultural buildings due to code exemptions. While technically true, this is unwise, especially for large barns, equipment storage, or facilities where people spend time.

Analogy to Safety Practices

Advising against engineering on the basis of exemptions is akin to suggesting people forgo seat belts or bike helmets if not legally required. It is always prudent to engineer structures for safety, regardless of code requirements.

Importance of Engineering Agricultural Buildings

Just as it makes sense to follow safety practices, it is advisable to fully engineer agricultural buildings, regardless of code exemptions. While fully engineered buildings may be more expensive for small structures, the difference is minimal for larger ones. Lower-priced, non-engineered buildings are often less safe because they lack balanced design. Non-engineered structures may include unnecessary components, inflating costs, while omitting critical elements, endangering occupants.

Building codes set minimum standards, and most engineers design to meet—but not exceed—these requirements. Claims that engineered agricultural buildings are excessively designed are unfounded.

Ethical Responsibility in Engineering Agricultural Buildings

Ethical Considerations for Builders

It is unethical to sell large agricultural buildings that are not fully engineered. Failing to do so puts farmers at risk and is responsible for the deaths of numerous animals each year.

Consequences of Inadequate Engineering

Tragic outcomes have resulted from lack of engineering, including collapses that killed thousands of chickens and cattle. For example, dozens of animals have died in partial collapses of non-engineered post-frame buildings.

Advice for Consumers

Farmers should always request written confirmation that their buildings are designed to meet the International Building Code’s structural criteria. Demanding documentation ensures the safety and durability of agricultural structures.

Ensuring Proper Engineering Documentation

All agricultural building documentation should be sealed by a qualified, registered professional engineer (P.E.), and for post-frame buildings, by a structural engineer specializing in post-frame design. It is wise to request sealed copies of structural calculations and plans, just as would be required for non-exempt buildings.

Risks Associated with Non-Engineered Designs

Be cautious of builders using designs and materials supplied only by local lumber yards; the engineering is often minimal. Receiving plans does not guarantee proper engineering.

Industry Reputation on the Line

Every major storm that causes post-frame building failures damages the industry's reputation and prompts scrutiny from architects, code officials, insurers, and consumers.

Industry Impact and Concerns Regarding Building Failures

When post-frame buildings fail, insurance premiums rise even for fully engineered structures. Initiatives to promote the industry, such as the Post Frame Marketing Initiative (PFMI), are undermined by recurring failures. Large building failures are increasing, doubling the risk of structural failure as structures grow in size. Failures in large buildings are especially concerning due to greater potential loss of life. Some stakeholders have suggested ending code exemptions for large agricultural buildings, though the real issue is improper engineering and construction, not regulatory gaps.

Proposal for NFBA Certification Program

The National Frame Building Association (NFBA) could improve safety and reputation by creating a formal certification program. Fully engineered buildings would receive "Engineering and Construction (E&C) Certification" upon completion, verified by an independent professional. Insurance companies could offer lower rates for certified buildings, based on reduced failure rates. Farmers could request E&C certification for assurance, benefiting builders, insurers, the NFBA, and farmers. Only those who risk lives with poor practices would be disadvantaged.

Advantages of Fully Engineered Post-Frame Buildings

Modern fully engineered post-frame buildings far outperform older versions. While some lament that "barns aren't built like they used to be," today's structures offer impressive size, clearspan distances, and load-bearing capabilities. Efficient material use keeps costs low and enhances durability and environmental sustainability, making fully engineered post-frame buildings among the most sustainable options available.

About the Author

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